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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	Priatna et al.
Serial No.	:	10/710,555
Filed	:	July 20, 2004
For	:	SYSTEM AND METHOD FOR MR DATA ACQUISITION WITH UNIFORM FAT SUPPRESSION
Group Art No.	:	3737
Examiner	:	John Fernando Ramirez

CERTIFICATION UNDER 37 CFR 1.8(a) and 1.10

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APPEAL BRIEF PURSUANT TO 37 C.F.R §41.37

Dear Sir:

This Appeal Brief is being filed in furtherance of the Notice of Appeal filed on January 29, 2009.

1. REAL PARTY IN INTEREST

The real party in interest is General Electric Company by virtue of the Assignment recorded July 21, 2004, at reel 014875, frame 0607.

2. RELATED APPEALS AND INTERFERENCES

Appellant is unaware of any other appeals or interferences related to this Appeal. The undersigned is Appellant's legal representative in this Appeal. General Electric Company, the Assignee of the above-referenced application, as evidenced by the documents mentioned above, will be directly affected by the Board's decision in the pending appeal.

3. STATUS OF CLAIMS

Claims 1-9, 12-13, and 15-28 are currently pending and are currently under final rejection. Claims 1-9, 12-13, and 15-28 are the subject of this appeal. Claims 10, 11 and 14 have been canceled.

4. STATUS OF AMENDMENTS

All previous amendments have been entered. Appellant has submitted no additional amendments subsequent to the Final Office Action of October 30, 2008.

5. SUMMARY OF CLAIMED SUBJECT MATTER

Claim 1 calls for a method of medical imaging comprises the steps of zero-filling (70) at least a first portion of k-space (72), applying a fat suppression pulse (82) to suppress signals from fat in an ROI and acquiring MR data from the ROI prior to full fat recovery (84) with a 3D fast gradient echo sequence (FGRE). *Specification*, ¶¶[0030]-[0031]; FIG. 3. The method also comprises the steps of filling at least a second portion of k-space from the MR data and reconstructing a uniformly fat-suppressed medical image from the MR data having fat magnetization suppressed below a uniform threshold above which the fat magnetization is deemed to have fully recovered. *Id.* at ¶¶[0031], [0035]; FIG. 4.

Claim 18 calls for a magnetic resonance imaging (MRI) apparatus (10) to reconstruct MR images with substantially uniform fat suppression comprising an MRI system (10) having a plurality of gradient coils (50) positioned about the bore of a magnet (54) to impress a polarizing magnet field and an RF transceiver system (58) and an RF switch (62) controlled by a pulse module to transmit RF signals to an RF coil assembly (52) to acquire MR images. *Specification*, ¶¶[0023]-[0024]; FIG. 2. The MRI apparatus (10) also comprises a computer (20) programmed to define an ROI to be sampled for MR data acquisition and select a slice direction. *Id*. at ¶[0022]; FIG. 2. The computer (20) is further programmed to zero fill at least a portion of k-space in the slice direction, and apply a fat suppression pulse to suppress signals from fat in the ROI. *Id*. at ¶¶[0030]-[0031]. Also, the computer (20) is programmed to acquire MR data from the ROI prior to full fat recovery, and repeatedly apply the fat suppression pulse and acquire MR data to fill a remainder of k-space with less-than-full-fat-recovery. *Id*. at ¶¶[0031], [0035]; FIG. 4.

Claim 23 calls for a computer readable storage medium (28, 30) that includes a computer program stored thereon. *Specification*, ¶[0025]; FIG. 2. The computer readable storage medium (28, 30) represents a set of instructions that when executed by a computer (20) causes the computer (20) to define a slice direction and zero fill less than an entirety of k-space in the slice direction. *Id*. at ¶¶[0034]-[0035]. The set of instructions further cause the computer (20) to apply a fat suppression pulse to suppress fat signals within an ROI, acquire MR data from the ROI prior to full recovery of magnetization of fat within the ROI, and repeat application of the fat suppression pulse and data acquisition to fill a remainder of the entirety of k-space with less-than-full-fat-recovery MR data. *Id*. at ¶¶[0030]-[0031], [0035]; FIGs. 3 & 4.

6. **GROUNDS OF REJECTION**

Whether claims 1, 12, and 16 are unpatentable under 35 U.S.C. §103(a) over Ma (USP 6,016,057) in view of Weiss (U.S. Pub. 2005/0165294) and further in view of Kwok et al. (USP 6,373,249).

Whether claims 2-9, 13, 15, and 17 are unpatentable under 35 U.S.C. §103(a) over Ma in view of Weiss and further in view of Haacke et al. (Magnetic Resonance Imaging, Haacke, E., et al., John Wiley and Sons, 1999) (hereinafter Haacke et al.).

Whether claims 18-27 are unpatentable under 35 U.S.C. §103(a) over Ma in view of Haacke et al.

Whether claim 28 is unpatentable under 35 U.S.C. §103(a) over Kassai et al. (US Pub. 2002/0188190) in view of Kwok et al.

7. <u>**ARGUMENTS**</u>

<u>**Rejection under 35 U.S.C. §103(a) over Ma in view of Weiss and further in view of Kwok et al.**</u>

<u>Claim 1</u>

The Examiner rejected claim 1 under 35 U.S.C. §103(a) as being unpatentable over Ma in view of Weiss and further in view of Kwok et al. Claim 1 calls for, in part, acquiring MR data from a ROI prior to full fat recovery and reconstructing a uniformly fat-suppressed medical image from the MR data having fat magnetization suppressed below a uniform threshold above which the fat magnetization is deemed to have fully recovered.

In rejecting claim 1, the Examiner asserted that "data from the ROI must inherently be acquired at some point prior to full fat recovery, because in principle full fat recovery takes an infinite time to occur." *Final Office Action*, 10/30/08, pg. 3. The Examiner admitted that the Ma/Weiss combination "does not explicitly disclose providing a threshold to define when the fat magnetization is deemed to have fully recovered." *Id.* at pg. 4. The Examiner, however, alleged that Kwok et al. discloses "a threshold to define when the fat magnetization is deemed to have fully recovered (col. 8, lines 51-67, col. 9, lines 1-11)." *Id.* The Examiner further alleged that it "would have been obvious to a person having ordinary skill in the art at the time the invention was made to provide a threshold to suppress noise and provide a mechanism for deciding the optimum number of pulses to use to suppress the signal from fat, as taught by Kwok et al." *Id.* Appellant respectfully disagrees.

First, Appellant believes the Examiner's reliance on the statement that "data from the ROI must inherently be acquired at some point prior to full fat recovery..." is improper. According to MPEP §2112, "[i]n relying upon the theory of inherency, the examiner must provide a basis in fact and/or technical reasoning to reasonably support the determination that the allegedly inherent characteristic <u>necessarily</u> flows from the teachings of the applied prior art." *Ex parte Levy,* 17 USPQ2d 1461, 1464 (Bd. Pat. App. & Inter. 1990) (emphasis in original). The Examiner stated that "in principle full fat recovery takes an infinite time to occur." However, the Examiner has provided no evidence or technical reasoning to support this conclusion of inherency. In fact, Appellant believes that the Examiner's assertion is simply illogical. Those skilled in the art of MR imaging are well versed in the concept of spin "recovery" in general, and it does not take a spin an infinite time to recover. Inverted fat magnetization recovers over time from a point where fat magnetization is zero to a steady state magnetization or full fat recovery point. *See Specification*, ¶[0006]; FIG. 1. Even the basic definition of the word "recovery" is inconsistent with the Examiner's interpretation. To recover means to "return to former state" and "to regain a normal position or condition." *See MSN Encarta Dictionary,* www.encarta.msn.com; *Merriam-Webster Dictionary*, www.merriam-webster.com/dictionary.

That is, contrary to the Examiner's statement, those skilled in the art of MR imaging will recognize that full fat recovery does <u>not, in fact,</u> take an infinite time to occur. Since the Examiner has provided no support for this inherency assertion, and since it is an interpretation that is at odds with the specification, common definitions, and what those skilled in the art readily recognize, the Examiner's conclusion of inherency is improper.

Second, Appellant believes the Examiner has misinterpreted the teachings of Kwok et al. in order to reflect that called for in claim 1. Kwok et al. teaches a system where, "the background noise of the water-only and fat-only images is removed by setting an intensity threshold just above the noise level before image combination." *Kwok et al.*, col. 8, ln. 66 – col. 9, ln. 1. The <u>intensity threshold</u> taught by Kwok et al., however, is a <u>noise suppression</u> feature (not a fat suppression feature) used when reconstructing interleaved water-only and fat-only MR images. Noise is not a measure of

fat magnetization. Therefore, a threshold intended to reduce background noise is not a fat magnetization threshold called for in claim 1.

Furthermore, Kwok et al. explains that the "SNR of the 3-DIWFAC water-plus-fat image is lower than that of the non-fat-suppressed GRE image by a factor of √2 due to the summation of noise from both the water-only and fat-only images." *Id.* at col. 8, lns. 62-66 (emphasis added). In other words, the water-plus-fat image of Kwok et al. has more noise than the non-fat-suppressed GRE image. Thus, Kwok et al. teaches setting the intensity threshold "above the noise level before image combination so that the water-plus-fat image has a similar SNR as the non-fat-suppressed GRE image." *Kwok et al.*, col. 8, ln. 66 – col. 9, ln. 3 (emphasis added). That is, Kwok et al. sets an intensity/noise level threshold when combining data from the water-only and fat-only images and only uses data above that intensity/noise level threshold in image combination. Claim 1, however, calls for reconstructing an image from MR data having fat magnetization suppressed below a uniform threshold, thus improving image contrast. Because the art of record fails to teach using data below a threshold to reconstruct a uniformly fat-suppressed image and because a threshold for noise-suppression cannot be interpreted to be a threshold for fat magnetization recovery, Appellant believes that the art of record fails to teach that called for in claim 1 and that it would not have been obvious to one of ordinary skill in the art to combine the teachings of Kwok et al. with those of Ma and Weiss to produce that called for in claim 1. As such, Appellant requests withdrawal of the rejection of claim 1, and all claims depending therefrom, under 35 U.S.C. §103(a) as being unpatentable over Ma in view of Weiss, and further in view of Kwok et al.

Rejection under 35 U.S.C. §103(a) over Ma in view of Haacke et al.

Claim 18

The Examiner rejected claim 18 under 35 U.S.C. §103(a) as being unpatentable over Ma in view of Haacke et al. Claim 18 calls for, in part, a computer programmed to define an ROI to be sampled for MR data acquisition, select a slice direction, zero fill at least a portion of k-space in the slice direction, and apply a fat suppression pulse to suppress signals from fat in the ROI. Claim 18 further calls for the computer to be programmed to acquire MR data from the ROI prior to full fat recovery, and repeatedly

apply the fat suppression pulse and acquire MR data to fill a remainder of k-space with less-than-full-fat-recovery.

In the rejection of claim 18, the Examiner admitted that “Ma does not explicitly disclose zero-filling in the slice direction or repeated application of the fat suppression pulse,” but alleged that Haacke et al. discloses “zero-filling of 3D data in the slice direction (p. 812).” *Final Office Action*, supra at pg. 10. Responsive to Appellant’s arguments filed on 07/09/08, the Examiner stated that the “**slice** select gradient is a magnetic field gradient applied to select the **slice** position in the **direction** of this gradient (x-**direction**).” *Id.* at pg. 2 (emphasis in original). The Examiner further alleged that “Haacke et al discloses an inversion recovery sequence using repeated application of the fat suppression pulse every TR seconds (Figure 17.6, page 429).” *Id.* at pg. 10. The Examiner also alleged that “it would have been obvious to one of ordinary skill in the art at the time of the invention to modify the invention of Ma to include zero-filling of 3D data to improve the apparent resolution of the image in the slice direction,” and to “modify the Ma/Weiss combination to use repeated application of the fat-suppression pulse because the fat magnetization recovers somewhat over time and it becomes necessary to re-suppress it using another fat-suppression pulse.” *Id.*

First, Appellant notes that, while the Examiner made reference to modifying the Ma/Weiss combination in support of the rejection of claim 18, on page 9 of the Final Office Action the Examiner indicated that claim 18 was rejected under §103(a) over Ma in view of Haacke et al. Thus, the Weiss reference was not included in the substantive rejection. Therefore, Appellant’s remarks below are directed to the substantive rejection over Ma in view of Haacke et al.

Second, Appellant believes the Examiner improperly stretched the teachings of Haacke et al. Although Haacke et al. discloses zero-filling, Haacke et al. makes no reference to zero-filling in the slice direction. In fact, the term “zero filling” appears only once in the passage cited by the Examiner.

> If the central k-space data has a gain of 96dB, say, and the DIFT is taken by <u>zero filling</u> the missing (but to-be-collected data) then the central point s(0) with value $N^2\rho_0\Delta x\Delta y$ transforms to ρ_0 in the image domain for all x, y.

Haacke et al., pg. 812 (emphasis added). There is no indication in the cited passage that the zero-filling mentioned is in the slice direction. Zero-filling in the slice direction maintains high in-plane spatial resolution while reducing scan time, as described in the Specification. *See Specification*, ¶[0034].

Although the Examiner stated that the "**slice** select gradient is a magnetic field gradient applied to select the **slice** position in the **direction** of this gradient (x-**direction**)" (*Final Office Action*, supra at pg. 2 (emphasis in original)), a direction of zero-filling is <u>not</u> disclosed or suggested in Haacke et al. While Haacke et al. may disclose "zero filling the missing (but to-be-collected data)" on pg. 812 as quoted above, Haacke et al. does not suggest a direction for zero-filling the missing data at all. *See Haacke et al.*, pg. 812. Also, the Examiner implied that Haacke et al. teaches that the slice direction is the x-direction. However, nowhere on pg. 812 does Haacke et al. even mention a slice direction.

As Haacke et al. does not disclose zero-filling in the slice direction, it would not have been obvious for one of ordinary skill in the art to combine the teachings of Haacke et al. with those of Ma to derive the subject matter of claim 18, as suggested by the Examiner. Because the cited references do not teach, suggest, or disclose each and every element called for in claim 18, Appellant believes claim 18, and all claims depending therefrom, are patentably distinct from that disclosed in Ma and Haacke et al., either alone or in combination.

<u>**Rejection under 35 U.S.C. §103(a) over Ma in view of Haacke et al.**</u>

<u>Claim 23</u>

The Examiner also rejected claim 23 under 35 U.S.C. §103(a) as being unpatentable over Ma in view of Haacke et al. Claim 23 calls for a computer readable storage medium having a computer program stored thereon and representing a set of instructions that when executed by a computer causes the computer to define a slice direction, zero fill less than an entirety of k-space in the slice direction, and apply a fat suppression pulse to suppress fat signals within an ROI. Claim 23 further calls for a computer readable storage medium having a computer program stored thereon that when executed by a computer causes the computer to acquire MR data from the ROI prior to

full recovery of magnetization of fat within the ROI, and repeat application of the fat suppression pulse and data acquisition to fill a remainder of the entirety of k-space with less-than-full-fat-recovery MR data.

In the rejection of claim 23, the Examiner repeated the argument made with respect to claim 1 that "in principle fat takes an infinite length of time to fully recover and therefore data is always acquired prior to full fat recovery." *Final Office Action*, supra at pg. 11. Thus, the Examiner concluded that "Ma inherently discloses acquiring MR data prior to full fat recovery (or "less-than-full-fat-recovery")." *Id*. Also, the Examiner again admitted that "Ma does not explicitly disclose zero-filling in the slice direction or repeated application of the fat suppression pulse." *Id*. The Examiner alleged that "Haacke et al disclose zero-filling of 3D data in the slice direction (p. 812)" and "an inversion recovery sequence using repeated application of the fat suppression pulse every TR seconds (Figure 17.6, page 429)." *Id*. at pgs. 11-12.

As explained above with respect to claim 1, under MPEP §2112, the Examiner must provide a basis in fact and/or technical reasoning when relying on a theory of inherency. Although the Examiner concluded that "Ma inherently discloses acquiring MR data prior to full fat recovery" because "in principle fat takes an infinite length of time to fully recover and therefore data is always acquired prior to full fat recovery" *(Final Office Action*, supra at pg. 11), the Examiner has provided no evidence or technical reasoning to support this conclusion of inherency. In fact, Appellant believes that the Examiner's statement regarding full fat recovery is inaccurate. That is, fat does <u>not</u> take an infinite length of time to fully recover. Accordingly, the Examiner's conclusion of inherency is improper.

Also, as set forth in detail above with respect to claim 18, while Haacke et al. uses the term "zero filling" one time in the passage cited by the Examiner, there is <u>no</u> indication that the zero filling mentioned by Haacke et al. is in the slice direction. Although, Haacke et al. generally suggests "zero filling the missing (but to-be-collected data)," the cited passage does not discuss or even mention slice direction or slice selection, much less teach zero filling less than an entirety of k-space in the slice direction as claimed.

Furthermore, contrary to the Examiner's statement, Haacke et al. does not suggest repeated application of a fat suppression pulse every TR seconds. Instead, at best, Haacke et al. suggests a fat excitation pulse followed by a fat saturation pulse. *See* Haacke et al., pg. 428, Fig. 17.5. Therefore, Haacke et al. does not teach or suggest repeating application of fat suppression pulses as called for in claim 23.

Also, while Haacke et al. may disclose collecting data at the zero crossing of fat, Haacke et al. does not teach a fat suppression pulse application procedure that applies a fat suppression pulse, acquires MR data prior to full recovery, and repeats application of the fat suppression pulse and data acquisition to fill a remainder of k-space as called for in claim 23.

Based at least on the above arguments, Appellant believes claim 23 and all claims depending therefrom are patentably distinct from that disclosed in Ma and Haacke et al., either alone or in combination. As such, Appellant respectfully requests withdrawal of the rejection of claim 23 under 35 U.S.C. 103(a) as being unpatentable over Ma in view of Haacke et al.

<u>Claim 25</u>

The Examiner also rejected claim 25 under 35 U.S.C. §103(a) as being unpatentable over Ma in view of Haacke et al. Claim 25 depends from claim 23 and calls for, in part, determining a flip angle of the fat suppression pulse such that the fat is at or near its null point at the filling of a center of k-space.

The Examiner admitted that "Ma does not explicitly disclose filling the center of k-space when the signal from fat is near its null point." *Final Office Action*, supra at pg. 12. The Examiner, however, alleged that "Haacke et al discloses determining a flip angle (inversion, Figure 17.6, p. 429) for the fat magnetization, followed by collecting data near the null point of the fat magnetization." *Id.* The Examiner further stated that it would have been obvious "to modify Ma to collect central k-space data near the null point of the fat magnetization because it is where the fat signal is smallest, resulting in best contrast between fat and water." *Id.*

As discussed above with respect to claim 18, at Fig. 17.6, Haacke et al. states that "[i]f data can be collected at the zero crossing (null point) of fat $T_1 = t_{null,f}$ or water $T_1 =$

$t_{null,w}$ that particular tissue can be suppressed from the image." *Haacke et al.*, pg. 429, Fig. 17.6. However, while Haacke et al. may suggest collecting data at the zero crossing or null point of fat, Haacke et al. does not disclose determining a flip angle such that fat is at or near a null point when the center of k-space is filled as called for in claim 25. In fact, the term "flip angle" is not even mentioned on page 429 of Haacke et al. While Haacke et al. may use the term "flip angle" on other pages of the publication, nowhere does Haacke et al. teach or suggest determining a flip angle of the fat suppression pulse such that the fat is at or near its null point at the filling of a center of k-space as called for in claim 25.

Also, Appellant believes the Examiner improperly interpreted that called for in claim 25. Claim 25 calls for more than a flip angle and data collection near the null point of fat magnetization. Specifically, claim 25 is directed to determining the flip angle such that the null point of the fat magnetization occurs when the center of k-space is filled. In other words, claim 25 determines a flip angle such that when the phase encoding scheme fills the center of k-space, fat magnetization is at or near the null point.

The combination of Ma and Haacke et al. suggested by the Examiner, on the other hand, modifies a phase encoding scheme as a function of the flip angle. Specifically, the Examiner interpreted Haacke et al. to teach determining a flip angle for fat magnetization and modified Ma based on the interpretation of Haacke et al. to collect k-space data near the null point of fat magnetization. Thus, the combination of Ma and Haacke et al. by the Examiner results in a method of filling k-space that essentially alters the sequence of data collection such that the center of k-space is filled when fat magnetization is at a null point. Accordingly, while the Examiner's assertion of Ma and Haacke et al. calls for determining acquisition of the center of k-space based on fat magnetization, claim 25, in contrast, is directed to determining a flip angle of a fat suppression pulse such that the null point of the fat occurs at or near the filling of the center of k-space.

As neither Haacke et al., Ma, nor a combination thereof, teach or suggest determining a flip angle for a fat suppression pulse such that fat is at or near a null point when the center of k-space is filled, Appellant believes that the art of record fails to teach that called for in claim 25. Accordingly, Appellant requests withdrawal of the rejection of claim 25, and all claims depending therefrom.

Claims 26 and 27

Claims 26 and 27 were also rejected under 35 U.S.C. §103(a) as being unpatentable over Ma in view of Haacke et al. The Examiner stated that claims 26 and 27 "are rejected for reasons similar to those stated with regard to claims 24 and 25 above, wherein the flip angle is determined as a function of a sequential sampling encoding scheme." *Final Office Action*, supra at pg. 13.

Claim 26, which depends from claim 25, calls for, in part, the flip angle determined as at least a function of one of a segmented sequential encoding scheme a reverse sequential encoding scheme. Claim 27, which depends from claim 26, calls the flip angle being set to 100 degrees for the sequential encoding scheme and set to more than 100 degrees for the reverse sequential encoding scheme.

Haacke et al. discloses three "different ordering schemes for the phase encoding gradient table": a sequential ordering scheme, a centric reordering scheme, and a reverse-centric reordering scheme. *Haacke et al.*, pg. 192. However, nowhere does Haacke et al. correlate the determination of a flip angle with a specific ordering scheme. At best, Haacke et al. suggests correlating a flip angle with time between the $\pi/2$ and α-pulses. Specifically, Haacke et al. states that the "$\pi/2$-pulse is usually made somewhat larger in flip angle to account for fat regrowth at the α-pulse." *Id.* at pg. 428. Thus, while Haacke et al. may suggest determining flip angle based, in part, on time, Haacke et al. does not teach or suggest determining the flip angle as a function of one of a segmented sequential encoding scheme and a reverse sequential encoding scheme as called for in claim 26.

Also, the mere disclosure by Haacke et al. of both a flip angle and phase encoding schemes would not lead one of ordinary skill in the art to determine a flip angle according to one of Haacke et al.'s disclosed phase encoding schemes. In fact, the two concepts are discussed in completely different sections of Haacke et al. (phase encoding schemes are discussed in Chapter 10-"Multi-Dimensional Imaging," while the first discussion of flip angle occurs in Chapter 17-"Water/Fat Separation Techniques"), thus lending to the non-obviousness of determining a flip angle according to one of the phase encoding schemes.

The Examiner appears to have relied on word searching as a basis for the rejection and has not provided any link between these two different sections of Haacke et al.

Furthermore, as discussed with respect to claim 25, at best, a combination of Ma with the flip angle determined by Haacke et al. determines <u>an ordering scheme for acquiring the center of k-space</u> as a function of the flip angle. Claim 26, on the other hand, calls for a determination of <u>a flip angle</u> at least as a function of a specific encoding scheme.

Regarding claim 27, the Examiner cited to Section 18.1.1 of Haacke et al. as supporting the statement that

> [t]he exact value of flip angle used to accomplish fat nulling is an obvious design choice that will depend on the particular value of TR chosen for the sequence, on the value of T1 for the fat being suppressed, and on the interval between the flipping pulse and the instant when fat nulling is desired, as discussed in Haacke et al (Section 18.1.1, pp. 454-460).

Final Office Action, supra at pg. 13. However, contrary to the Examiner's assertion, Section 18.1.1 does not discuss determining a flip angle to accomplish fat nulling based on T_1 and T_R. Instead, Section 18.1.1 is directed to an expression for the steady-state incoherent (SSI) signal and plots image or voxel signal as a function of flip angle for fatty tissue using a 20 ms T_R. *See* Haacke et al., Fig. 18.3(c). While Haacke et al. may refer to a flip angle for fatty tissue, Haacke et al. does not teach or suggest a flip angle set to a first value for a segmented sequential encoding scheme and set to a different range of values for a reverse sequential encoding scheme. The only mention of a specific flip angle in Haacke et al. refers to the "zero crossing of the SSI signal for all tissues when the flip angle equals 180°" and that "[f]or θ=20°, good T_1-weighted contrast is obtained between GM and WM. CSF is suppressed further and fat now has the highest signal." *Haacke et al.*, pg. 458; Fig. 18.3c. Nowhere does Haacke et al. suggest that the value of flip angle is set or determined based on a However, while Haacke et al. may suggest a flip angle of 20 degrees or 180 degrees, Haacke et al. does not teach or even suggest the flip angle is set to either 20 degrees or 180 degrees based on a segmented sequential encoding scheme or a reverse sequential encoding scheme.

Additionally, as stated above with respect to claim 26, Haacke et al. does not teach or suggest determining flip angle based on any specific encoding scheme. In fact, nowhere in Section 18.1.1 is signal encoding even mentioned. Accordingly, Haacke et al.

does not teach or suggest setting the flip angle to a first value, i.e., 100 degrees, for the segmented sequential encoding scheme and setting the flip angle to a different value, i.e., more than 100 degrees, for the reverse sequential encoding scheme as claimed.

Rejection under 35 U.S.C. §103(a) over Kassai et al. in view of Kwok et al.

Claim 28

The Examiner rejected claim 28 under 35 U.S.C. §103(a) as being unpatentable over Kassai et al. in view of Kwok et al. Claim 28 calls for an MR apparatus comprising means for exciting nuclei to precess at a given Larmor frequency when subjected to a substantially uniform magnetic field, and means for fastly acquiring 3D MR data only when fat magnetization is suppressed below a full-recovery threshold during breathhold moments.

In rejecting claim 28, the Examiner admitted that "Kassai et al does not explicitly disclose providing a threshold below which the fat magnetization is considered to be suppressed." *Final Office Action*, supra at pg. 13. However, as in the claim 1 rejection, the Examiner alleged that Kwok et al. "discloses a threshold to define when the fat magnetization is deemed to have fully recovered (col. 8, lines 51-67, col. 9, lines 1-11)." *Id*. The Examiner also alleged that "[i]t would have been obvious to a person having ordinary skill in the art at the time the invention was made to provide a threshold to suppress noise and provide a mechanism for deciding the optimum number of pulses to use to suppress the signal from fat, as taught by Kwok et al." *Id.*

As explained above with respect to claim 1, Kwok et al. teaches a system in which background noise is removed from images by setting an intensity threshold just above a noise level before image combination. *See Kwok et al.*, col. 8, ln. 66 – col. 9, ln. 3. The intensity threshold taught by Kwok et al. is a noise suppression feature used when combining data from water-only and fat-only images. Specifically, Kwok et al. sets the intensity threshold above the noise level and only uses data above that intensity/noise threshold in image combination. The full-recovery threshold called for in claim 28, on the other hand, is related to suppression of fat magnetization, as opposed to suppression of noise as taught by Kwok et al. Further, claim 28 calls for acquiring data only when fat magnetization is suppressed below the full-recovery threshold. Thus, the noise-

suppressing threshold of Kwok et al., above which data is used, cannot be interpreted to be a full-recovery threshold below which fat magnetization is suppressed for data acquisition, as called for in claim 28.

The Examiner erred in equating the noise-suppressing intensity threshold taught by Kwok et al. with the full-recovery threshold called for in claim 28. As neither Kassai et al. nor Kwok et al. disclose a full-recovery threshold as claimed, Appellant believes a combination of the art of record fails to teach, disclose, or suggest that called for in claim 28. Accordingly, Appellant requests withdrawal of the rejection of claim 28 under 35 U.S.C. 103(a) as being unpatentable over Kassai et al. in view of Kwok et al.

8. **CONCLUSION**

For at least the reasons set forth above, Appellant requests withdrawal of the rejection of claims 1-9, 12-13, and 15-28. Appellant believes that the Examiner has not shown that the art of record teaches each and every limitation of the claims so as to make the claims obvious. As such, Appellant believes that claims 1, 18, 23, 28, and the claims which depend therefrom, are patentably distinct over the art of record.

Appellant appreciates the Board's consideration of these Remarks and respectfully requests timely issuance of a Notice of Allowance.

Respectfully submitted,

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9. **CLAIMS APPENDIX**

1. A method of medical imaging comprising the steps of:

zero-filling at least a first portion of k-space;

applying a fat suppression pulse to suppress signals from fat in an ROI;

acquiring MR data from the ROI prior to full fat recovery with a 3D fast gradient echo sequence (FGRE);

filling at least a second portion of k-space from the MR data; and

reconstructing a uniformly fat-suppressed medical image from the MR data having fat magnetization suppressed below a uniform threshold above which the fat magnetization is deemed to have fully recovered.

2. The method of claim 1 wherein the step of acquiring MR data includes segmenting data acquisitions into a number of imaging segments for each phase encoding view, and acquiring multiple slice encoding lines per imaging segment, and further comprising the steps of repeating application of the fat suppression pulse for MR data acquisition for each imaging segment.

3. The method of claim 2 further comprising the step of filling each phase encoding view of k-space with fat-suppressed MR data.

4. The method of claim 3 wherein the step of filling includes sampling MR signals from the ROI with a segmented sequential encoding order having a k-space trajectory starting at or near a center of k-space to a periphery of k-space.

5. The method of claim 4 further comprising the step of determining a flip angle for the fat suppression pulse such that magnetization of fat within the ROI is at or near a null point at the filling of the center of k-space.

6. The method of claim 3 wherein the step of filling includes sampling MR signals from the ROI with a reverse segmented sequential encoding order having a k-space trajectory from a periphery of k-space to at or near a center of k-space.

7. The method of claim 6 further comprising the step of determining a flip angle for the fat suppression pulse such that magnetization of fat within the ROI is at or near a null point at the filling of the center of k-space.

8. The method of claim 1 wherein the step of zero-filling includes zero-filling in a slice direction.

9. The method of claim 1 wherein the fat suppression pulse includes a spectrally-selective inversion recovery pulse.

10-11. (Canceled)

12. The method of claim 1 further comprising the step of acquiring the MR data during at least one of a breathhold and a non-breathhold moment.

13. The method of claim 1 further comprising the step of sequentially sampling the ROI and sequentially filling the non-zero filled portions of k-space.

14. (Canceled)

15. The method of claim 1 further comprising the step of defining a 3D volume of interest (VOI), and wherein the step of acquiring MR data includes the acquisition of 3D data from the VOI.

16. The method of claim 1 wherein the step of acquiring MR data includes sampling MR signals from an excited region surrounding one of a liver or breast region of a medical patient.

17. The method of claim 1 further comprising the step of reconstructing a magnetic resonance angiography (MRA) image from the MR data.

18. A magnetic resonance imaging (MRI) apparatus to reconstruct MR images with substantially uniform fat suppression comprising:

an MRI system having a plurality of gradient coils positioned about the bore of a magnet to impress a polarizing magnet field and an RF transceiver system and an RF switch controlled by a pulse module to transmit RF signals to an RF coil assembly to acquire MR images; and

a computer programmed to:

define an ROI to be sampled for MR data acquisition;

select a slice direction;

zero fill at least a portion of k-space in the slice direction;

apply a fat suppression pulse to suppress signals from fat in the ROI;

acquire MR data from the ROI prior to full fat recovery; and

repeatedly apply the fat suppression pulse and acquire MR data to fill a remainder of k-space with less-than-full-fat-recovery.

19. The MRI apparatus of claim 18 wherein the computer is further programmed to acquire the MR data during at least one of a breathhold and a non-breathhold moment.

20. The MRI apparatus of claim 18 wherein the computer is further programmed to sequentially fill the non-zero filled portions of k-space.

21. The MRI apparatus of claim 18 wherein the computer is further programmed to reconstruct a fully fat-suppressed medical image from the MR data.

22. The MRI apparatus of claim 18 wherein the fat suppression pulse includes a spectrally-selective inversion recovery pulse.

23. A computer readable storage medium having a computer program stored thereon and representing a set of instructions that when executed by a computer causes the computer to:

define a slice direction;

zero fill less than an entirety of k-space in the slice direction;

apply a fat suppression pulse to suppress fat signals within an ROI;

acquire MR data from the ROI prior to full recovery of magnetization of fat within the ROI; and

repeat application of the fat suppression pulse and data acquisition to fill a remainder of the entirety of k-space with less-than-full-fat-recovery MR data.

24. The computer program of claim 23 wherein the computer is further caused to acquire MR data with one of segmented sequential encoding, reverse segmented sequential encoding, and centric encoding of k-space.

25. The computer program of claim 23 wherein the computer is further caused to automatically determine a flip angle of the fat suppression pulse such that fat is at or near its null point at the filling of a center of k-space.

26. The computer program of claim 25 wherein the flip angle is determined as at least a function of one of a segmented sequential encoding scheme and a reverse sequential encoding scheme.

27. The computer program of claim 26 wherein the flip angle is set to 100 degrees for the segmented sequential encoding scheme and set to more than 100 degrees for the reverse sequential encoding scheme.

28. An MR apparatus comprising:

means for exciting nuclei to precess at a given Larmor frequency when subjected to a substantially uniform magnetic field; and

means for fastly acquiring 3D MR data only when fat magnetization is suppressed below a full-recovery threshold during breathhold moments.

10. <u>EVIDENCE APPENDIX:</u>

-- None --

11. **RELATED PROCEEDINGS APPENDIX:**

-- None --